AN EXPERIMENTAL STUDY ON THE DEVELOPMENT OF THE DWARF TAPEWORM (*HYMENOLEPIS NANA*)

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The course of infection and the development of the dwarf tapeworm have been much studied and discussed, especially as to whether this species has any intermediate host or not, but as yet no definite conclusion has been reached. I have studied this subject extensively, both in animals and in man.

From my experiments it appears that the eggs of this tapeworm, unlike those of others, can hatch and develop without any intermediate host.

ON THE DEVELOPMENT OF THE DWARF TAPEWORM IN ITS HOSTS

1. *From five hours to twenty-four hours after feeding.*

On examining mice which had swallowed dwarf tapeworm eggs five or six hours previously, I observed in their small intestines six-hooked larvae, all of which had emerged from the egg-shells. After ten hours the mice had larvae which had already entered into the villi in the upper part of the small intestine and from hour to hour, up to twenty to twenty-four hours, larvae penetrated the villi. These larvae were oval or round in shape, their surface was granulated and they had six hooks near one end.

2. *Three days after feeding.*

I found many larvae in the villi; their shape was the same as noticed above but they had increased in size. Most of them were somewhat pear-shaped. In the centre of their bodies the granules

became somewhat coarse and I observed some small calcareous corpuscles which reflected the light strongly, but as yet the larvae were not encysted.

3. *Four days after feeding.*

The six-hooked larvae, which had entered the villi, had increased much in size and became bean-shaped encysted larvae (Cysticercus), the space between the body of the larva and the cyst being filled with granular material. Some, still with six hooks at one end of the cyst, were moving in the villi.

In the centre of the body of the larvae was a ring of regularly arranged wedge-shaped hooks, which reflected the light strongly ; but the roots of the hooks were not yet separated and the differentiation of the suckers was not clearly defined ; however, by carefully adjusting the light, I could see some encysted larvae with two suckers in front and some with only one ; and among the radiating fibres running from the caudal extremity of the encysted larva to the cyst, could be found irregularly-shaped calcareous corpuscles, some large, some small.

4. *Five days after feeding.*

Well developed encysted larvae had emerged from their cysts, left the villi, descended to the lower part of the small intestine and were actively moving about, extending and contracting themselves ; some were in process of emergence from their cysts and some had already emerged, still having parts of the cysts attached at the rear. In these larvae I could see four suckers ; a single ring of hooks, an excretory tube, running from the rear of the rostellum to the caudal extremity, and some irregularly-shaped calcareous corpuscles which reflected the light strongly.

5. *Eight days after feeding.*

The size has increased and segments are clearly seen, but there is no differentiation of the reproductive organs.

6. *Ten days after feeding.*

A gradual increase in size ; the uteri being filled with what seemed to be primitive eggs, the structure of which was not very clear.

7. *Fourteen days after feeding.*

Growth is complete and the posterior gravid segments are so full of eggs that the testes are compressed and the excretory tubes obscure.

8. *Fifteen to nineteen days after feeding.*

Although there was some difference in the development of the dwarf tapeworms according to the host employed (mice, rats) they grew little by little, and about the seventeenth or eighteenth day, the experimental animals began to evacuate eggs in the faeces.

After eighteen days the last segments of the adult tapeworms become more slender, as the result of having discharged many eggs.

EXPERIMENTAL INFECTION IN MONKEYS

15 June, 1919. Two young male monkeys (one year and two months old), showing no tapeworms' eggs in their faeces, were obtained. I made one of the monkeys swallow many eggs of the dwarf tapeworm, but found no eggs on examining its faeces fifteen to sixteen days after the feeding ; so I again made it swallow many eggs. It was killed seven days later ; the contents and villi of its small intestine were closely examined, but no dwarf tapeworms were to be found.

26 July, 1919. The other monkey was fed with many dwarf tapeworms' eggs ; it became gradually feeble, and died in about six days. Examination of its small intestine showed thirteen young dwarf tapeworms in the lower part, the shape and size being no different from those of the young dwarf tapeworms in the small intestine of the mice and rats.

SWALLOWING OF EGGS BY MAN

29 January, 1919. Taking great care not to destroy the eggs of the dwarf tapeworm, I washed them with water, put many of them into capsules and swallowed them myself.

As a control, a part of the same material was given to a rat and a white rat which seven days later proved to be infected, but in spite of having examined my own faecal matter several times, for fourteen or fifteen days after ingestion, I could not find any dwarf

tapeworm eggs. Then I tried to expel tapeworms from my intestine, but unsuccessfully. Afterwards I swallowed eggs three times but neither eggs nor worms were found in my faeces.

Fortunately, a girl four years old was available for experiment; she was strongly-built, well nourished and healthy. I carefully examined her faeces several times, and each time found a few eggs of Ascaris but none of the dwarf tapeworm. On 12 April, 1919, she swallowed many eggs of the dwarf tapeworm in capsules and afterwards her faeces were examined on many occasions. On the first of May, nineteen days later, I found a few eggs of the dwarf tapeworm, and upon expelling the worms from her small intestine, I secured ninety-seven adult dwarf tapeworms.

SUMMARY

1. The six-hooked larvae of the dwarf tapeworm, about ten hours after ingestion, penetrate the villi in the upper part of the small intestine and four days later become encysted larvae (Cysticercus). Five days after ingestion, well developed larvae emerge from their cysts and leave the villi.

2. After seven days, well developed young dwarf tapeworms have some segments at the end of the body.

3. After nine days, their reproductive organs become visible.

4. About fourteen days after ingestion, the segments are full of eggs, in each of which can be seen a six-hooked larva (Onchosphere).

5. After about seventeen days, the ripe eggs of the dwarf tapeworms are found in the faeces of the experimental animals.

6. These experiments show that dwarf tapeworm eggs which have been evacuated with the faeces of the host, are swallowed by animals or man with their food, and that the eggs hatch and the six-hooked larvae are liberated in the small intestines, and later enter the villi of the small intestines where they become encysted larvae; then emerging from the cysts they grow into young dwarf tapeworms and upon maturity evacuate the ripe eggs.

7. Therefore, without any intermediate host, the dwarf tapeworm can directly develop in the body of mice, rats, young monkeys, or man, especially children.